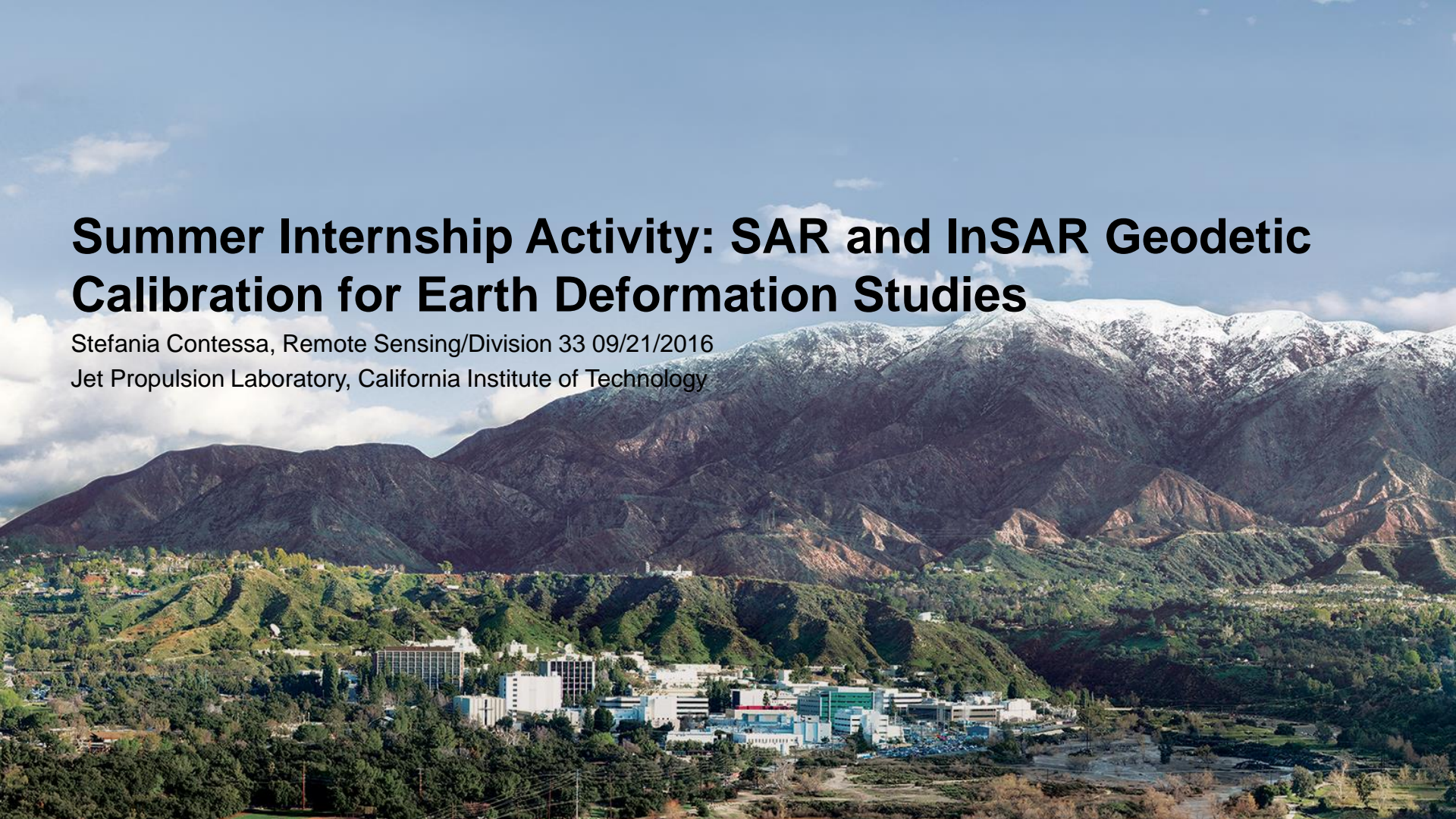


# Summer Internship Activity: SAR and InSAR Geodetic Calibration for Earth Deformation Studies

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Jet Propulsion Laboratory, California Institute of Technology



# My work at JPL



**GOAL:** using Sentinel and Cosmo-SkyMed data to determine geolocation accuracy of SAR imagery.

Using ground calibration points that are known to mm precision and are measured continuously over time to characterize the geodetic quality of images and how it changes over time.

**ISCE** (Interferometric Scientific Computing Environment)

Study of California area



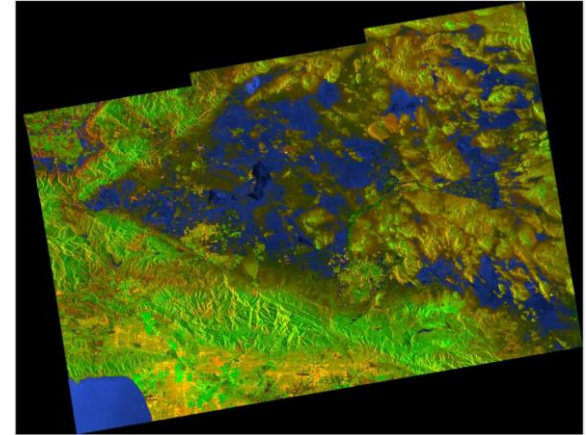
# Site of Interest



## Rosamond (CA), USA



## SLC image analyzed



### Sentinel-1A

S1A\_IW\_GRDH\_1SDV\_20151216T015000\_20151216T015025\_009061\_00D021\_65F3

Beam mode: IW

Frame: 109

Path: 64

Absolute Orbit: 9061

Acquisition Date: 2015-12-16

Ascending/Descending: Ascending

Frequency: C-Band

Polarization: VV+VH

Data courtesy of ESA

# Typical Rosamond Corner Reflector



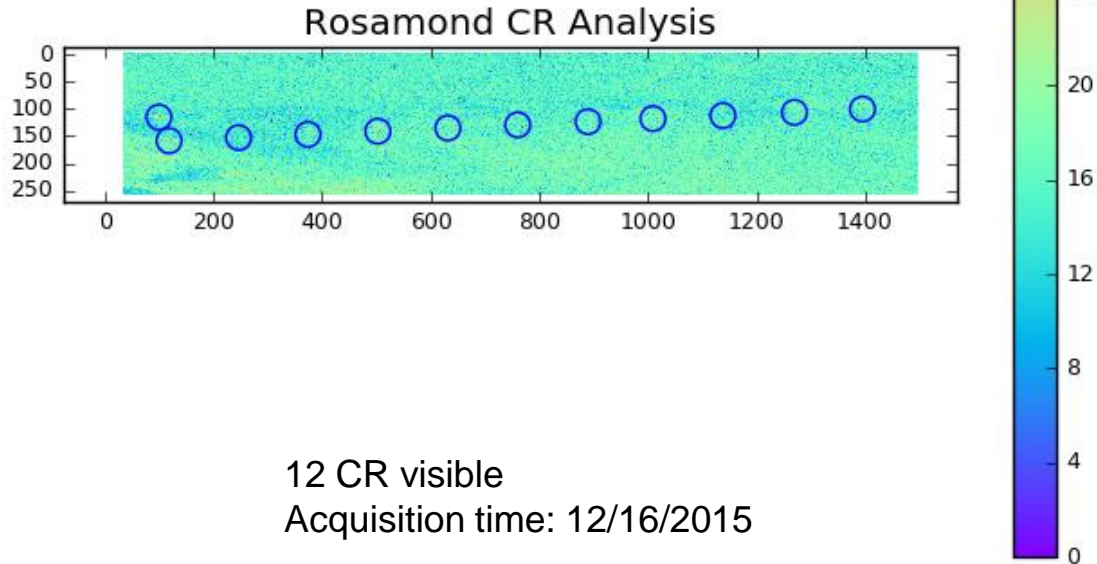
The coordinates listed here are in IGB08. They are expressed as WGS-84 geodetic latitude and height above the reference ellipsoid with  $a = 6378137$  m and  $f = 1/298.257222$ .

I used Orbital State Vectors (OSVs) *precise*.  
OSVs *restituted* only for the most recent image.

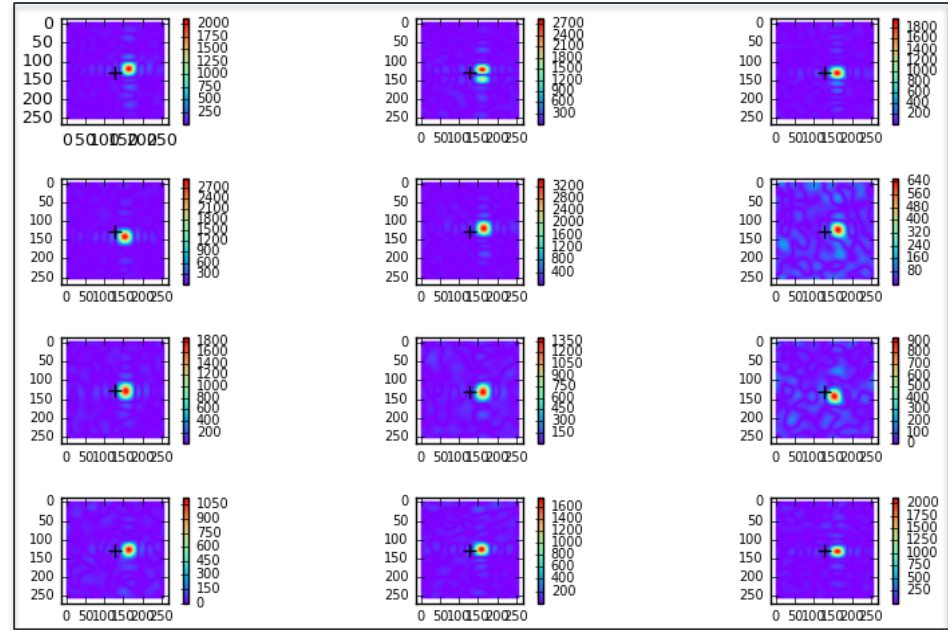
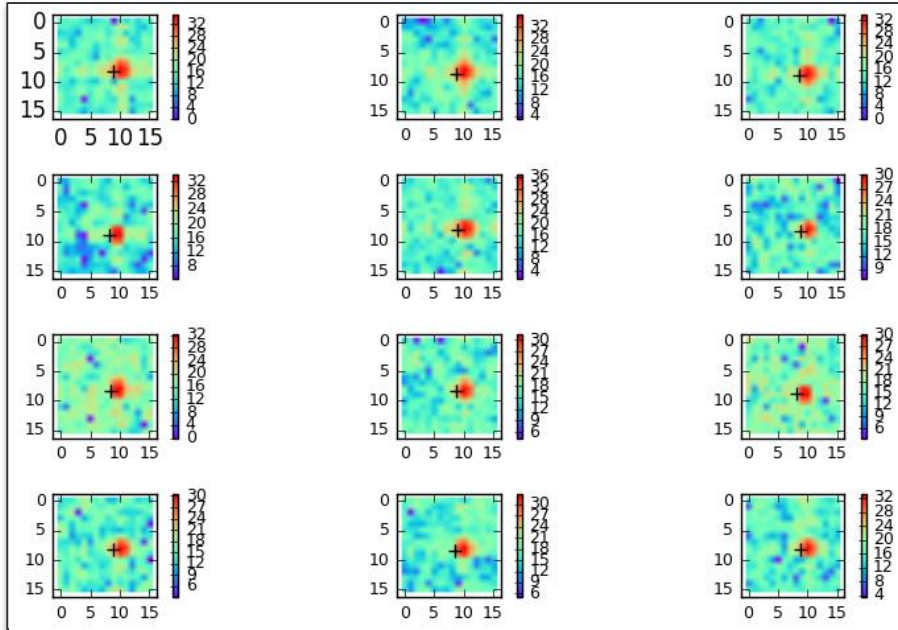
Corner reflector number	Geodetic latitude	Longitude	Elevation (m)	Orientation (deg)	Elevation angle (deg)	Side length (m)
0	34.796968	-118.0965259	660.9047	171.83	11.43	2.4384
1	34.79976241	-118.0870473	661.0851	170.67	11.68	2.4384
2	34.80523651	-118.0874563	660.8863	170.67	12.34	2.4384
3	34.80534159	-118.0819065	661.0639	175.33	11.89	2.4384
4	34.80541462	-118.0763749	661.143	175	12.38	2.4384
5	34.80549289	-118.0708001	661.2326	171.33	10.1	2.4384
6	34.80558395	-118.0652228	661.2451	172	10.76	2.4384
7	34.80566908	-118.0596638	661.3144	173	11.59	2.4384
8	34.80575124	-118.0540701	661.4592	171.66	10.21	2.4384
9	34.80581331	-118.0489123	661.4532	174.67	8.45	2.4384
10	34.80592464	-118.043364	661.522	173.33	7.96	2.4384
11	34.80602337	-118.0376901	661.6029	170	8.19	2.4384
12	34.80604616	-118.0322784	661.9067	173.33	11.84	2.4384
13	34.80519087	-118.0844157	660.8183	349	13.86814	2.4384
14	34.80543974	-118.0789121	660.9549	350	9.047237	2.4384
15	34.80551809	-118.0733394	661.2359	350.75	7.35	2.4384
16	34.80554783	-118.0678661	661.2917	350.83	6.9	2.4384
17	34.80550096	-118.0624549	661.3198	351.67	11	2.4384
18	34.80568571	-118.0563896	661.3912	351.67	11.23	2.4384
19	34.80572179	-118.0518132	661.4171	351	11.56	2.4384
20	34.80583723	-118.0463549	661.4538	350	10.61	2.4384
21	34.8059005	-118.040331	661.4691	355	9.95	2.4384
22	34.80603087	-118.0350619	661.7198	354	10.59	2.4384
23	34.80250391	-118.0858021	661.2242	350.93	21.75	4.8
24	34.80290863	-118.0766439	661.4462	350.77	22.15	4.8
25	34.80315584	-118.0687772	661.5239	349.38	21.23	4.8
26	34.80322777	-118.06058	661.6443	350.7	22	4.8
27	34.80351914	-118.0522778	661.6858	350.22	22	4.8
28 (Key)	34.79894033	-118.0948046	661.5012	353.5	12.3	0.7
31 (Hello Kitty)	34.80122243	-118.0790931	661.8806	351	16.9	0.7
34 (Kite)	34.80349533	-118.0633906	661.9856	354	22.4	0.7
37 (Kangaroo)	34.80577869	-118.0476721	662.1196	350	28.4	0.7

From: <http://uavsar.jpl.nasa.gov/>

# Image processing

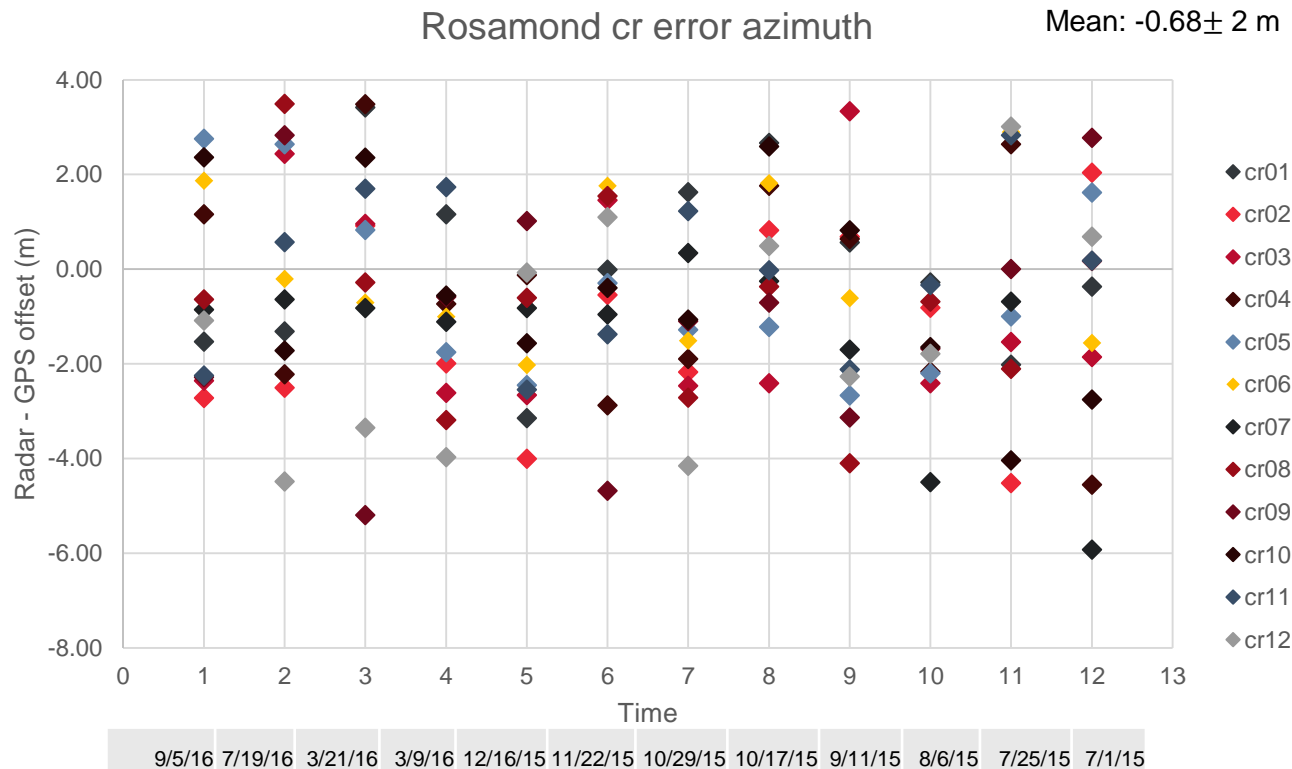


# Image processing



# Azimuth offset

Acquisition time: 09/05/16 – 07/01/15



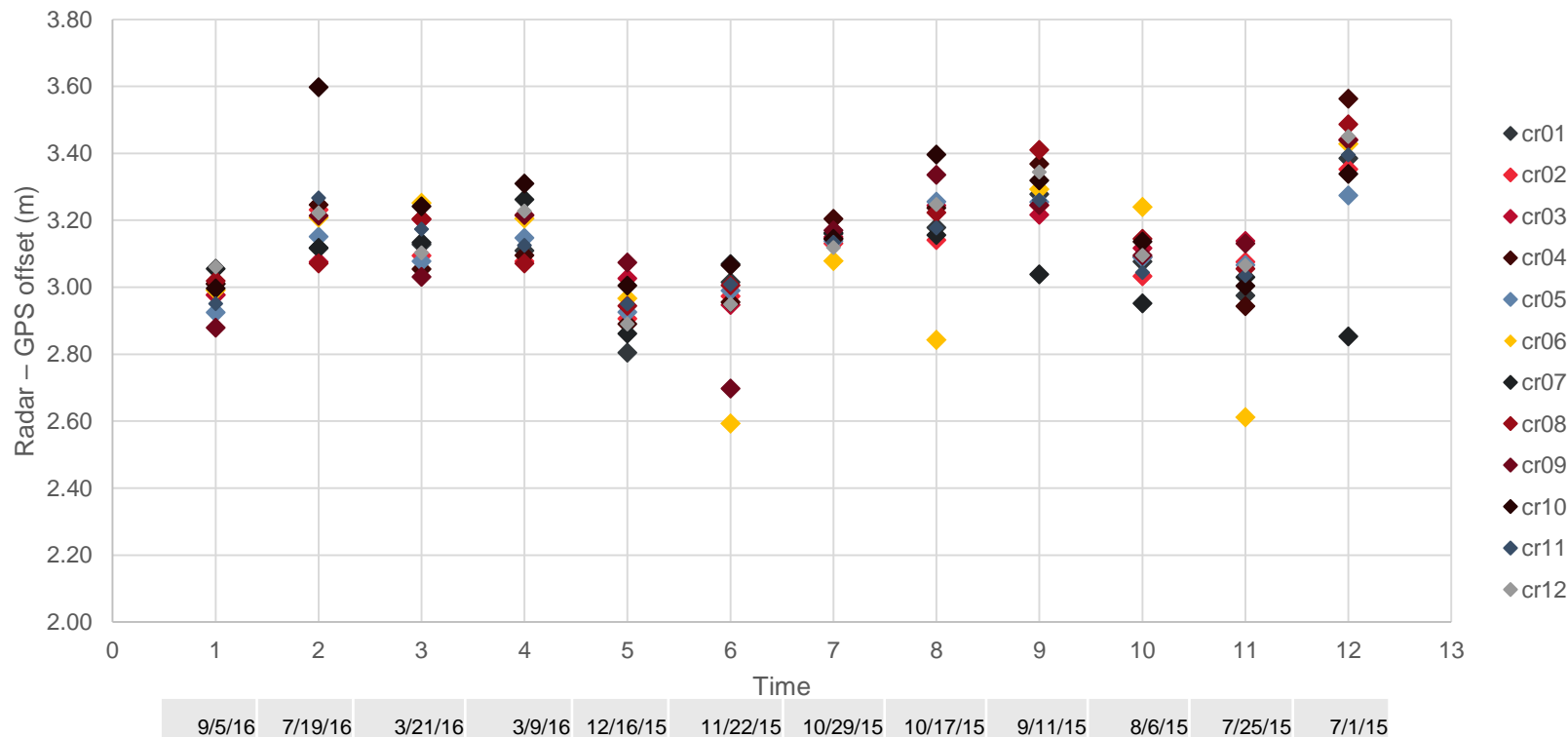


# Slant Range offset



Rosamond cr error slant range

Mean:  $2.77 \pm 0.1$  m

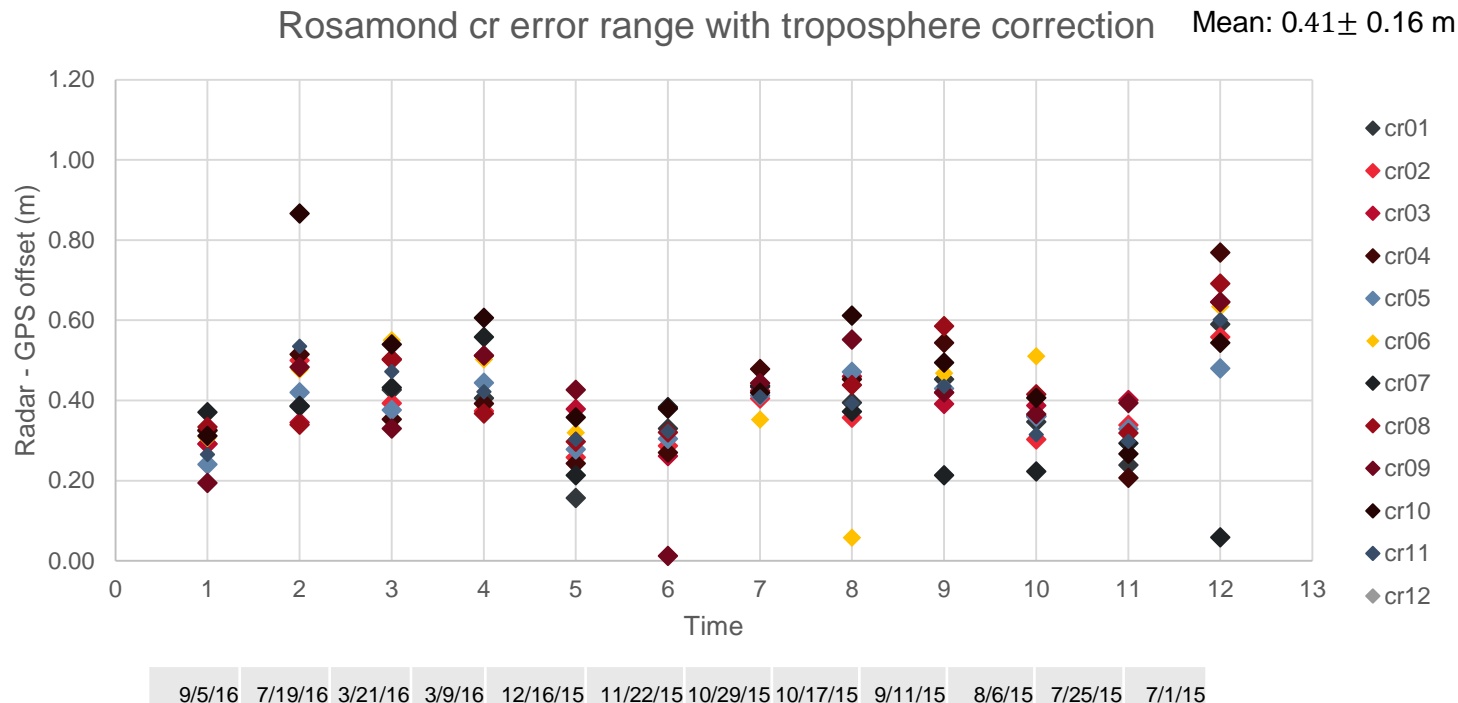




# Range offset with tropospheric correction



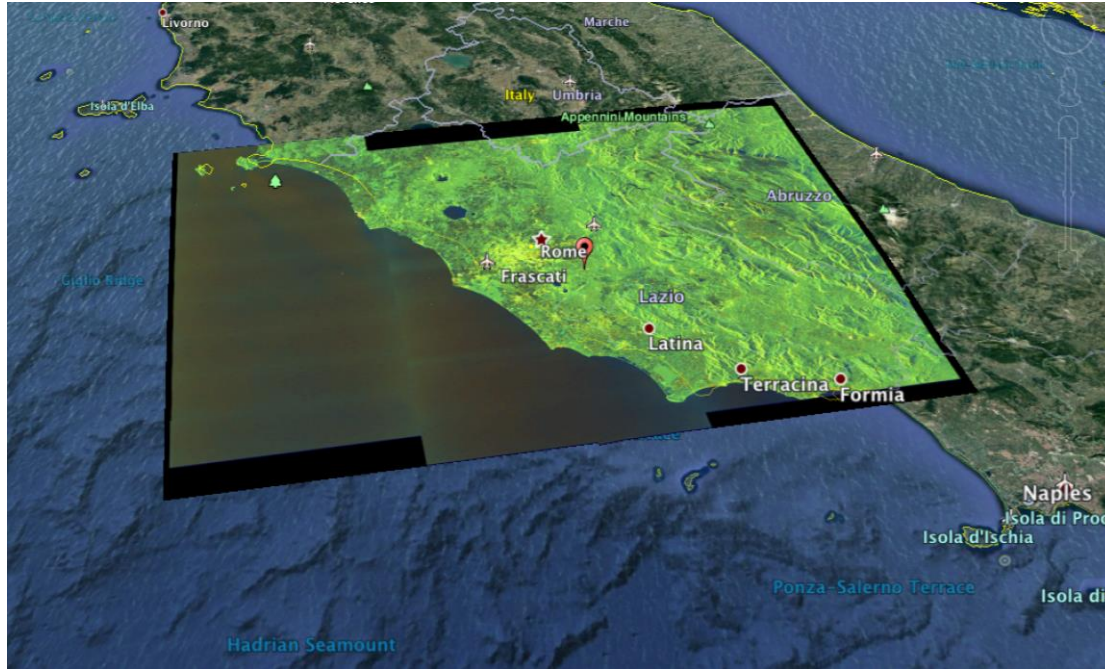
Tropospheric correction: vertical delay estimated from ECMWF and processing using PyAPS package



# Site of Interest



## Frascati (RM), Italy



SLC image analyzed



Sentinel-1A

S1A\_IW\_GRDH\_1SDV\_20160908T170528\_20160908T170553\_012964\_0148

Beam mode: IW

Frame: 135

Path: 117

Absolute Orbit: 12964

Acquisition Date: 2016-09-08

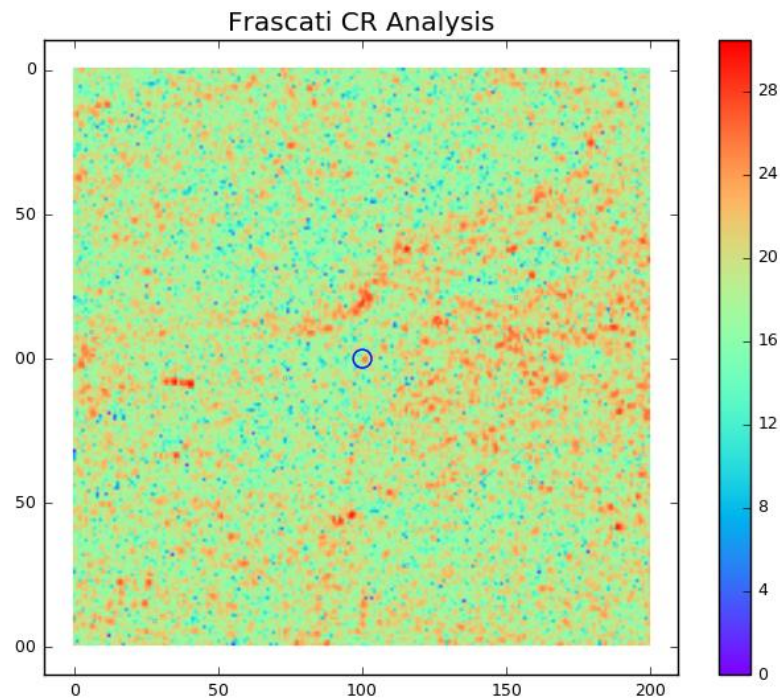
Ascending/Descending: Ascending

Frequency: C-Band

Polarization: VV+VH

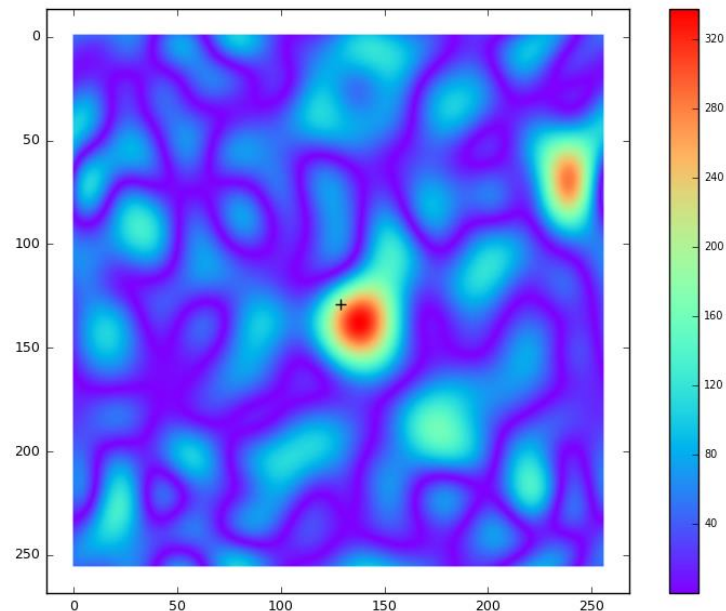
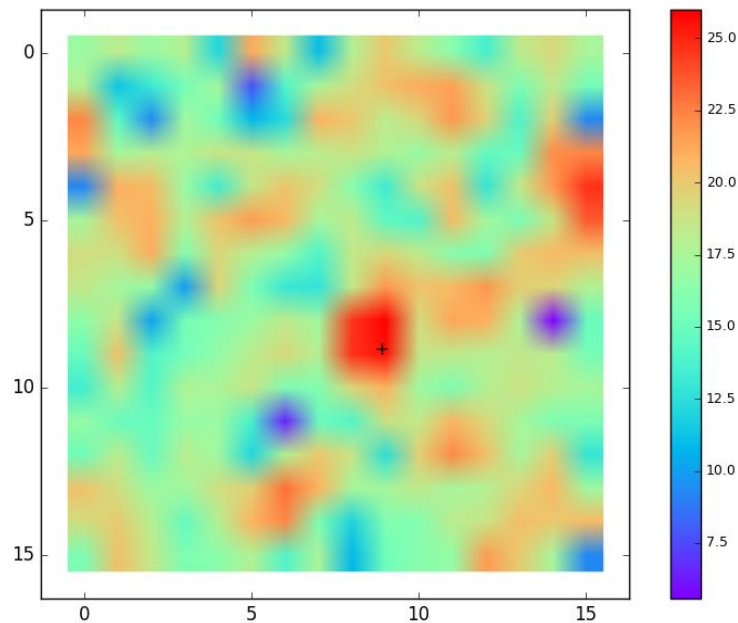
Data courtesy of ESA

# Image processing



INCA GPS position:  
Lat= 41.7890417  
Long= 12.6645794  
Height= 353.8305  
It is not a DGPS

# Image processing



Radar-GPS offset azimuth= -1.0692343188643119 m

Radar-GPS offset slant range= -0.6041091858864442 m



# Conclusions and future work



- ✓ Geolocation accuracy of Sentinel TOPS images
- ✓ Mean of azimuth offset is  $-0.68 \pm 2$  m , mean of slant range offset  $2.77 \pm 0.1$  m
- ✓ Good reduction of slant range offset with tropospheric correction to  $0.41 \pm 0.16$  m
- ✓ There are consistent with previous analysis conducted on STRIPMAP images by ESA and University of Zurich. Azimuth  $1.82 \pm 0.44$  m, Slant Range  $1.79 \pm 0.37$  m.
- ✓ Investigation of error trend in slant range
- ✓ Investigation of other perturbation/delay
- ✓ INCA deployment in some other areas with a flatter or radar absorbing background to investigate its performances and at the ASI-Matera Laser Station
- ✓ Implementation of a tool for Cosmo-SkyMed data and analysis of image for INCA detection
- ✓ Open Call ASI for Cosmo-SkyMed images acquisition